REMARKS

Applicants acknowledge receipt of the Final Office Action dated March 19, 2004, in which the Examiner rejected all pending claims as obvious in view of Schweitzer et al in view of Clark et al and further in view of Eri et al. Applicants submit herewith three Affidavits in rebuttal of that rejection. Applicants respectfully request that the Examiner review the attached Affidavits and then reconsider and withdraw these rejections for the following reasons prior to commencement of an Appeal.

Amendment Of Two Claims Under 1.116(b)

Applicants intended to cancel claim 50 in the previous Response and have done so in the present response.

Claim 20 has been amended to correct an obvious typographical error.

No other amendments have been made.

The Prior Art does not suggest the use of a gas Peclet number Peg less than 0.175

None of the cited references, taken alone or together, provide a teaching or suggestion of the presently claimed invention. Rather, as discussed in detail below, the state of the art at the time of the present invention was uniformly directed to plug flow operation of slurry bubble column reactors.

As noted by the Examiner in the previous Office action, Schweitzer teaches a process for synthesizing hydrocarbons by reacting a mixture comprising at least carbon monoxide and hydrogen in the presence of a catalyst. Schweitzer teaches that the process is carried out in a three-phase reactor in which the liquid Peclet number is in the range of from 0 (excluded) to about 10. Notably, Schweitzer teaches the use of a superficial gas velocity U_g less than 35 cm/s so as to avoid too much attrition of the catalyst grains.

Schweitzer's sole mention of the gas Peclet number Pe_g, which is indicative of the degree of mixing that is present in the gas flow, occurs in paragraph [0018], as noted by the Examiner. Paragraph [0018] is a summary of EP-B-0 450 860, which in turn corresponds to U.S. Patent 5,348,982 to Herbolzheimer. Schweitzer itself is silent as to a preferred value for Pe_g. On the other hand, Herbolzheimer expressly teaches away from the use of operating in the well-mixed regime. Herbolzheimer explicitly states that,

> "Optimum performance of slurry bubble column reactors requires adequate fluidization of the catalyst particles while minimizing backmixing of the reactants in the gas phase." (EP'860, page 4, line 15). (emphasis added).

According to Herbolzheimer, the optimal method includes:

"injecting the gas phase into a column...with and appropriate velocity so that the solid phase is fluidized while still maintaining 'plug flow' reactor behavior over the column length." (EP'860 page 5, line 25). (emphasis added).

Thus Herbolzheimer, which is the sole cited reference that provides any explicit teaching regarding the gas Peclet number, teaches fluidizing catalyst particles in order to operate under plug flow conditions. Schweitzer neither adds to nor contradicts Herbolzheimer's teachings. Thus, Herbolzheimer embodies the state of the art.

Neither Clark nor Eri add any technical information regarding the flow regime or degree of mixing during operation of a slurry bubble column. Clark teaches a staged Fischer-Tropsch process carried out in a series of reactors and states that "Carbon monoxide conversions are typically less than 70% for each reactor stage, and more preferably in a range of from about 40 to about 60% for each reactor stage." Clark merely suggests that the reactors may be slurry bubble column reactors. Since carbon monoxide conversions less than 70% can be achieved using a variety of techniques including catalyst selection, operating temperature and pressure, reactor residence time, and feedstock limitations, the teachings of Clark do not relate to mixing at all, let alone provide any suggestion of the desirability of operating in the well-mixed regime.

Similarly, and as noted by the Examiner, Eri teaches the use of a gaseous hourly space velocity, based on the total amount of synthesis gas feed, of between 100 and 20,000 cm^3 of gas per gram of catalyst per hour and more preferably from 1000 to 10,000 $cm^3/g/h$. Again, however, Applicants respectfully point out that the mere disclosure of a preferred operating range for the gas hourly space velocity of the feed says nothing about the fluid flow regime.

The degree of back-mixing that occurs in a given reactor is the result of not only the flow rate of gases through the reactor, but also the reactor aspect ratio, the configuration of the reactor internals such as cooling coils, and the densities of each of the phases present in the reactor. Thus the teachings of Eri are not relevant to the obviousness of the present claims.

The Affidavits

As evidence that the state of the art did not include an appreciation of the merits of operating with the gas-phase in the well-mixed regime, Applicants submit herewith three affidavits. Each affidavit describes, in the words of the affiant, the state of the art with respect to the operation of slurry bubble column reactors. Each affiant declares that, until reviewing the concepts disclosed in the present patent application, he, along with others skilled in the art, understood that optimal operation of a slurry bubble column reactor occurred in the plug flow regime.

Specifically, Professor Milorad Dudukovic, who is the Laura and William Jens Professor and Chairman of the Department of Chemical Engineering at Washington University, and Professor Calvin Bartholomew, who is in the Department of Chemical Engineering and Head of the Catalysis Laboratory at Brigham Young University, and R. Ameri David, who is a graduate student in Chemical Engineering at the California Institute of Technology (Caltech), have each reviewed the present application and to opine on the obviousness of the claims in view of the cited art.

As illustrated by their titles and the accomplishments listed on their respective affidavits, each of these men is highly regarded within the chemical engineering community and has particular knowledge relating to the field of slurry bubble column reactors.

Reasons Affidavits not Previously Submitted

Applicants submitted an Affidavit signed by one of the present inventors with their previous Response, in the expectation that the statements therein would convince the Examiner that the present claims are not obvious. In the face of the continued rejection on the same grounds in the current Final Office Action, Applicants have now turned to affiants outside Applicants' organization.

Because of the significant investment in time required to review the issues and prepare an affidavit, and because Applicants expected to persuade the Examiner with the previously submitted evidence, Applicants did not undertake to obtain third-party affidavits at the time of filing the previous response. In order to overcome the continued rejection, Applicants now submit the third-party Affidavits, which Applicants submit provide incontrovertible evidence in support of Applicants' position. Applicants therefore respectfully request that the Affidavits be admitted and considered by the Examiner prior to or in the course of an Appeal.

Case Law

Recent case law supports Applicants' position regarding obviousness. "[I]n general, a reference will teach away if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the applicant." *In re Gurley*, 27 F.3d 551, 553, 31 USPQ2d 1130, 1131 (Fed. Cir. 1994). At column 3, lines 36-42, EP '860, the only reference that discusses the significance of the gas Peclet number, states:

> The important difference between the CSTR and plug flow reactor systems is that the gas phase reactant concentrations that provide the kinetic driving force for the reaction differ significantly. In the fully backmixed system, the reactant concentration is the same at every point in the reactor; in the plug flow system, the reactant concentration steadily decreases along the path of the catalyst bed from inlet to outlet and the reaction rate is obtained by integrating the rate function from inlet to outlet.

> Because the reactant concentration at any point in a CSTR system always corresponds to outlet conditions, the productivity in a fully backmixed system will always be lower than the productivity in a plug-flow system for reactions with positive pressure order kinetics. (emphasis added).

Clearly, the reference suggests that the use of slurry bubble column reactors having a well-mixed gas phase will not produce the desired result (productivity). As confirmed by the attached Affidavits, the understanding that was set out by Herbolzheimer and accepted among those skilled in the art, was that use of a well-mixed gas phase would not result in commercial success.

See also *Ecolochem, Inc. v Southern California Edison Co.*, 227 F.3d 1361 (Fed. Cir. 2000), copy attached, and in particular pages 5-7 of that opinion. In *Ecolochem*, the Federal Circuit reiterated that the combination of two prior art references does not render patent claims obvious if there is no evidence of any suggestion, teaching, or motivation to combine the information from the prior art and there is evidence that the prior art actually teaches away from the patented process. The facts in *Ecolochem* closely parallel the present case, in that the inventors have gone against the body of common knowledge and discovered how to create an advantageous process using concepts that had previously been discarded by others.

In view of the facts, including the state of the art in the relevant technology, and in view of the law relating to obviousness, the Examiner is respectfully requested to reconsider and withdraw the obviousness rejection.

Conclusion

Applicants respectfully submit that the present arguments and the attached Affidavits illustrate the non-obviousness of the pending claims and therefore request that the rejection be withdrawn and the claims allowed prior to commencement of the concurrently filed Appeal. If the Examiner has any questions regarding the foregoing, he is invited to telephone the undersigned at (713) 238-8043.

Respectfully submitted,

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Conley Rose, P.C.
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AGENT FOR APPLICANT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.: 10/023,258 **Confirmation No. 5940**
Applicant: Zhang et al.
Filed: December 14, 2001
TC/A.U.: 1621
Examiner: J. Parsa
Docket No.: 1856-2900 (9602.0-01)
Customer No.: 31889

AFFIDAVIT OF MILORAD P. DUDUKOVIC, PH.D.

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Atty. Dkt. No.
Date: September 10 , 2004

Sir:

1. I, Milorad P. Dudukovic, state as follows:

2. I am over 18 years of age and competent to make this Affidavit.

3. Currently, I am The Laura and William Jens Professor, Chairman of the Department of Chemical Engineering and Director of the Chemical Reaction Engineering Laboratory (CREL) at Washington University in St. Louis (WUSTL), Missouri. I have been at WUSTL since 1974.

4. I earned my Ph.D. in Chemical Engineering from the Illinois Institute of Technology(IIT) in Chicago, Illinois.

5. I have been actively involved in teaching, research and consulting in the field of multiphase reactors including slurry bubble columns for liquid phase methanol, DME and Fischer Tropsch synthesis. I have co-taught a short course for the American Institute of Chemical Engineers (AIChE) on multiphase reactors for a number of years and have served as a consultant to a number of companies on the subject of slurry bubble columns.

6. Under a subcontract with Air Products and Chemicals, Inc., I have worked on a five-year Department of Energy (DOE) project to study the hydrodynamics of slurry bubble columns and a second DOE project studying slurry bubble columns in Fischer Tropsch synthesis. The DOE subcontract (DE-FC25-95PC95051) via Air Products entitled "Slurry Bubble Column Reactor (SBCR) Fluid Dynamics ".

provided $1,980,000 in funding from October 1995 through February 2002. The University Coal Research (UCR) DOE Grant (DE-FG22-95PC95212), provided $500,000 in funding from 1996-1998 plus industrial cost sharing. Since 2000 CREL has continued the study of slurry bubble columns for Fischer Tropsch synthesis with sponsorship of five CREL supporting companies.

7. For my research and teaching accomplishments, I have received a number of awards and recognitions, which include the R.H. Wilhem Award of the AIChE (highest honor in reaction engineering) the ACS Man of the Year Award, and the Council for Chemical Research (CCR) Malcolm E. Pruitt Award. I have also been elected a foreign member of the Yugoslav Academy of Engineering and I am also a member of the St. Louis Academy of Science.

8. I am currently the Associate Editor of Industrial and Engineering Chemistry (IECR) and a Fellow of the AIChE.

9. I have been asked, as Consultant to ConocoPhillips, to examine the above cited application as amended (Serial No. 10/023,258, and hereinafter the "Zhang *et al.* patent application"), the Patent Office rejection notices and the prior patents relied on by the patent Examiner in the text of the rejection notices, and to provide my expert opinion as to what the prior art teaches a person having ordinary skill in the art and how those teachings compare with the methods claimed in the Zhang *et al.* patent application.

10. In my review of Schweitzer *et al.* (English language text US Patent Application 2003/0109590-A1) as compared to the Zhang *et al.* patent application, I find that this reference teaches...*liquid Peclet number "Pe_l is thus in the range 0 (excluded) to about 10, preferably in the range from about 0.005 to about 8, more preferably in the range from about 0.01 to about 5 and still more preferably in the range from about 0.02 to about 3, or even in the range from about 0.03 to about 1."*

11. In my review of Clark *et al.* as compared to the Zhang *et al.* patent application, I find that this reference teaches...*low conversion in each of a series of reactors, for the purpose of avoiding water gas shift; says nothing about gas space velocity, Peclet number or degree of mixing.*

12. In my review of Eri *et al.* as compared to the Zhang *et al.* patent application, I find that in this reference ...*Eri teaches only the use of a gas hourly space velocity ...between 100 and 20,000 cm^3 of gas per gram of catalyst per hour, more preferably from 1000 to 10,000 cm^3/g/h and says nothing about gas Peclet number or degree of mixing*

13. In my review of Herbolzheimer *et al.* (US Patent No. 5,348,982) as compared to the Zhang *et al.* patent application, I find that this reference teaches...*an FT slurry bubble reactor where the gas desirably moves up the column in plug flow. This reference discloses a very broad range of potential gas Peclet numbers*

between infinity down to a number greater than 0.2. I note that a gas at Peclet number near 0.2 is not plug flow, but much closer to a well mixed regime, but I assume that the discussion of Peclet number is designed to be as broad as possible for legal and patenting purposes.

14. Based on my knowledge of all other prior art, *...there is no reference that describes a method of operating a Fischer-Tropsch slurry bubble column reactor to have a gas Peclet number below 0.2 or that would lead the ordinarily skilled person to operate a Fischer-Tropsch slurry bubble column reactor so as to have a gas Peclet number below 0.2.*

15. In my review of the Patent Office rejection notices, it is my opinion that *...the Examiner erred in concluding that it would have been obvious to a person having ordinary skill in this art to operate a Fischer-Tropsch slurry bubble column reactor so as to have a low gas Peclet number, as the above patent references clearly direct skilled readers to operate in a plug flow operational regime for the gas which requires high gas Peclet numbers.. As it was the state of the art at that time to optimize conversion of the reactants as those reactants passed through the reactor, the ordinarily skilled person would have designed and operated the column so that the gas would move in plug flow. It would have been against conventional wisdom at the time for an ordinarily skilled person to operate the column to have gas moving in a high back-mixing regime. It appears to me that the Examiner is using the logic and rational set forth in the Zhang et al. patent application to conclude that invention is not patentable and not using any prior documents or references to arrive at this conclusion.*

16. It is my opinion that those with "ordinary skills in the art", even if well acquainted with bubble columns and Fischer Tropsch, would have been searching for plug flow behavior of the gas, misguided by existing patent literature. .

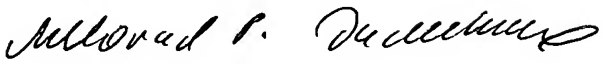
17. In contrast to what is taught by the prior patents, the current application teaches that high gas superficial velocities should be used in conjunction with column aspect ratios that optimize volumetric productivity. This requires operation at conditions of very high backmixing of the gas ($Pe < 0.175$) which is contrary to all previous publications that advocated approaching plug flow of the gas. In comparison with other patents granted in this area, the current application as amended, *is technically and distinctly different than prior known systems.*

DECLARATION

I hereby declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE

Full Name: Milorad P. Dudukovic, Ph.D.

Signature: 

Date: September 14, 2004

Country of Citizenship: United States

Residence Address:

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Crestwood, Missouri 63126-1627, USA

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 10/023,258
Applicant : Zhang et al.
Filed : December 14, 2001
TC/A.U. : 1621
Examiner : J. Parsa
Docket No. : 1856-23900 (9602.0-01)
Customer No.: 31889

AFFIDAVIT OF CALVIN H. BARTHOLOMEW, Ph.D.

STATEMENT OF PERSONAL FACTS

1. I, Calvin H. Bartholomew, Ph.D., state as follows:

2. I am over 18 years of age and competent to make this Affidavit.

3. I am a Professor of Chemical Engineering employed by Brigham Young University in Provo, Utah and Head of the BYU Catalysis Laboratory. I am also President and Principal Consultant of Bartholomew Consulting Services, Inc.

4. I earned my Ph.D. in Chemical Engineering from Stanford University, in Stanford, California.

5. I have taught undergraduate and graduate courses in Chemical Engineering, including chemical reaction engineering, kinetics, catalysis, and reactor design for over 30 years; I have also taught courses on these subjects to over 500 company professionals at several large companies.

6. I have conducted research in the fields of heterogeneous catalysis and catalyst/reactor design and modeling for 35 years with an emphasis on syngas production and conversion during the past 30 years; I am co-author of more than 125 journal papers and reviews addressing topics in these fields of research and technology; I am co-author of a comprehensive textbook/handbook treating fundamentals and practice of industrial catalytic processes.

7. I have consulted with more than 35 companies on problems relating to the science and practice in these fields.

8. I am familiar with the scientific and patent literatures treating the subject of slurry-bubble-column reactors (SBCRs) for Fischer-Tropsch synthesis; I am presently engaged in writing two comprehensive reviews of literature on this topic, one of which treats the operation and modeling of SBCRs with Mr. R.A. David and Prof. M. Dudukovic.

9. I have studied carefully each of the relevant patents cited below:

STATEMENT OF UNDERSTANDING OF THE SCOPE AND CONTENT OF PRIOR ART

10. The scope of the previous Slurry Bubble Column Reactor ("SBCR") art includes: (a) more than 400 published journal papers, proceedings, reviews, and reports; (b) an authoritative, comprehensive book by Deckwer, several authoritative reviews by Krishna et al., and a detailed model by Stern et al.; (c) dozens of early patents and reports detailing the practice of FT SBCRs in Germany from 1940-1960; and (d) approximately a dozen relevant patents and patent applications since 1990.

11. The content of pertinent prior patent art is largely embodied in USP 5,348,982 (Herbolzheimer and Iglesia, 1994) assigned to Exxon Research & Engineering Co., US Patent Application Publ. US 2003/0109590-A1 assigned to Schweitzer et al. (2003), USP 5,827,902 (Maretto et al.) assigned to AGIP, and USP 6,201,031 (Steynberg et al.) assigned to Sasol Technology. These documents are hereafter designated as USP-982, USAP-590, USP-902, and USP-031, respectively.

12. USP-982 teaches the desirability of operating a SBCR such that gas transport is in the "plug-flow" regime with the benefit of achieving low reactor volume at a high syngas conversion. In terms of Peclet numbers, perfect plug flow occurs at Pe = Infinity (∞), but USP-982 indicates that systems having Pe_g as low as $Pe_g > 0.2$ are sufficiently unmixed to achieve the desired level of syngas conversion.

13. USPAP-590 teaches the benefit of operating a SBCR with well-mixed liquid flow and makes reference to the European equivalent of USP-982 suggesting agreement with the desirability of gas plug flow. One particular relevant teaching (paragraphs 16 and 17) is that a well-mixed liquid phase reactor achieves high selectivity but "to the detriment of productivity" and that plug flow facilitates high productivity to the detriment of selectivity.

14. USP-902 describes advantages of operating a SBCR in several stages in series in which both gas and liquid phases are in essentially plug flow; advantages of plug flow operation are said to include higher conversion and productivity (at fixed inlet gas and liquid velocities).

15. USP-031 describes the advantages of using downcomer tubes in a SBCR in a churn-turbulent flow regime with large gas bubbles rising in a plug flow manner; advantages claimed include uniform distributions of catalyst and heat. It cites as a disadvantage, the back flow of gas in the form of small bubbles in a downcomer. Nevertheless, it finds that "by using downcomers at different vertical elevations, the degree of backmixing of the dense phase [liquid phase] gas can be decreased, thus enhancing the conversion performance of the reactor." In one example, Pe > 3 was measured at superficial gas velocities of 15-30 cm/s at 20 bar.

16. Reviews by Krishna et al. teach that optimum SBCR performance should be measured in terms of productivity (rather than conversion) and that higher gas velocities correlate with higher productivities. Moreover, they recommend large diameter (6-10 m) columns operating at high gas velocities (20-40 cm/s). However, Krishna et al. also advocate high conversion (e.g. 95%) and never specify Pe_g or the regime of flow for the gas.

17. Stern et al. suggest on the basis of their complex model that small diameter columns correspond to "the most efficient use of a given reactor volume"; this conclusion would be consistent with operation at a high Peclet number or plug flow.

18. Accordingly the prior art generally considers plug flow of the gas as desirable to achieve high conversion and optimum SBCR performance. USP-902 and USP-031, in fact, clearly endorse plug flow of the gas phase as optimal. Otherwise, there is confusion regarding the desirability of large or small diameter columns and the optimal range for gas velocity.

STATEMENT OF UNDERSTANDING OF DIFFERENCES BETWEEN THE PRIOR ART AND THE APPLICATION AT ISSUE

19. In my opinion, the prior art defines optimum performance of a SBCR in terms of maximizing syngas conversion at a given reactor volume. In contrast, the present application defines optimum performance in terms of maximizing productivity, while operating at a medium level of conversion (i.e., 30-70%). It is my opinion that this precise definition of the operating characteristics in combination with a SBCR is unique relative to the prior art.

20. The prior art teaches that plug flow of gas is optimum for the SBCR or otherwise doesn't specify the flow regime for the gas, while the subject application uniquely claims that mixed flow of gas is optimum for the SBCR. In other words, the prior patent art recommends operation of a SBCR at a gas Peclet number at least above 0.2 or otherwise doesn't specify Pe_g, while the application recommends operation at a gas Peclet number below 0.175.

21. In summary, the unique enabling features of the present application are (1) the specification of Pe_g *less than* 0.175, which maximizes productivity in the mixed gas flow regime, and (2) a specified gas velocity range of greater than 20 cm/s.

STATEMENT CONSIDERING OBJECTIVE EVIDENCE INDICATING NONOBVIOUSNESS OF THE APPLICATION OF ZHANG ET AL.

22. It is my opinion that the desirability of operating a SBCR with a gas Peclet number below 0.175 would not have been obvious to a person having ordinary skill in the art of catalysis and catalyst/reactor design because the pertinent literature teaches otherwise. For example, USP-982 (Claim 1) teaches the opposite ($Pe_g > 0.2$).

23. In my opinion, the benefit of operating in the mixed gas flow regime is unexpected and non-obvious.

24. Prior to seeing the application of Zhang et al. (first time in early June 2004), my understanding of the SBCR art was that embodied in USP-982, i.e., that the optimum design would call for operation of a SBCR at high conversion with plug flow of the gas. While I learned through one of my students in Summer 2003 of Krishna's statement that optimal performance is associated with high productivity and that high productivity is positively correlated with gas velocity, I did not conclude that mixed gas flow behavior was desired, or that a there was a maximum value of Pe_g. These facts only became apparent after I read the present patent application.

25. If someone had successfully extrapolated Krishna's statement to recognize the desirability of mixed gas flow and low Pe_g, this would by itself be *a necessary but not sufficient (nor enabling) condition* to claim this as a viable region of operation for a SBCR in Fischer-Tropsch synthesis, given significant limits on the understanding of this process.

26. In summary, I believe that the application of Zhang et al. sets forth new methods for operation of a SBCR for Fischer-Tropsch synthesis which provide significant improvements over the state of the art. Moreover, at the time this application was made, these novel improvements would NOT have been obvious to a person having ordinary skill in the art. Indeed, it is clear from the prior art that they were yet unrecognized by those highly skilled in the art.

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE

Full name: Calvin H. Bartholomew, Ph.D.

Signature: Calvin H. Bartholomew

Date: Sept. 15, 2004

Country of Citizenship: USA

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 10/023,258
Applicant : Zhang et al.
Filed : December 14, 2001
TC/A.U. : 1621
Examiner : J. Parsa
Docket No. : 1856-23900 (9602.0-01)
Customer No.: 31889

AFFIDAVIT OF RALPH L.A. DAVID

PERSONAL INFORMATION

- I, Ralph L. Ameri David, earned my B.S. in Chemical Engineering from BrighamYoung University in August 2003, with a cumulative GPA of 4.00/4.00.
- I am over 18 years of age and competent to make this Affidavit.
- I spent about 6 months in the summer 2003 studying the open literature for Fischer-Tropsch Synthesis in Slurry Bubble Column reactors (SBCRs); I read and/or studied between 300-400 papers and one book[1] (probably around 4000-5000 pages total), and I am writing a review with C.H. Bartholomew and M. Duducovic treating the operation of FT SBCRs.
- I am currently a graduate student in Chemical Engineering at the California Institute of Technology (Caltech.)

PRIOR ART:

A. From my review of the literature of SBCRs, it is clear to me that the gas Peclet number (Pe_G) is not the same as the liquid Peclet number (Pe_L).

- Deckwer's book[1] *Bubble Column Reactors* provides an excellent review of dispersion coefficients in the gas, liquid, and slurry (i.e. liquid + solid) phases, explaining the physical phenomena involved and how to measure/calculate Pe_G and Pe_L.
- Numerous correlations can be found in the open literature to calculate Pe_G and Pe_L.
- Generally speaking, Pe_G and Pe_L are very different in their numerical value for a given set of conditions; the difference can be substantial enough to achieve plug flow (PF) in the *gas* phase while the *liquid* phase is well mixed (near CSTR behavior.) Models assuming PF in the gas phase and CSTR behavior in the liquid have been proposed by Satterfield and Huff, Bukur, and Stern et al., and can be found in a review by Saxena[2].

[1] *Bubble Column Reactors*, W.D. Deckwer, Wiley, 1991

[2] S.C. Saxena, M. Rosen, D.N. Smith, J.A. Ruether, Mathematical Modeling of Fischer-Tropsch Slurry Bubble Column Reactors, Chem. Eng. Com. 40 1986 p. 97-151

B. From my review of the literature of SBCRs, the references generally teach away from causing backmixing of the gas in an SBCR.

- The Herbolzheimer et al. patent (US 5,348,982) assigned to Exxon indicates that optimum performance of an FT SBCR corresponds to plug flow of gas. This corresponds to $Pe_G, \rightarrow \infty$, although a broad range of values for Pe_G is included in the description and the range $Pe_G > 0.2$ is specifically disclosed.
- The Steynberg et al. patent (US 6,201,031) discloses a process by which a more uniform distribution of heat and of particulate catalyst can be achieved with the use of downcomers, howbeit with "the disadvantage of back flow of gas in the form of small bubbles." As explained on Col. 3, Lines 21-26, the process is intended to operate with the gas phase "traversing the reaction zone or slurry bed virtually in a plug flow manner." According to Steynberg et al. then, mixing in the gas phase is perceived as undesirable.
- The Maretto et al. patent (US 5,827,902) also teaches that "optimum operation" of a FT bubble column reactor is obtained with plug flow in the gas phase (see abstract; Col. 13, Lines 27-31; and Col. 14, Lines 13-15).

C. Although the prior art has established approximate lower and upper bounds on gas velocity and column size, for both these operating parameters the range of proposed values is very large.

- Krishna and coworkers[3][4][5] at the University of Amsterdam have predicted that an optimally designed FT SBCR would be 6-10 m in diameter, 30-40 m in height, and operate at gas superficial velocities in the 20-40 cm/s range.
- Schweitzer et al. (Pub. No. US 2003/0109590 A1) state that it would be advantageous to operate in reactors of diameters of more than 6 or 7 m (see paragraph [0047]) and at velocities $U_G < 35$ cm/s (see paragraph [0045].)
- Herbolzheimer et al. (USP '982) "require a design with intermediate values of the reactor diameter and gas velocity" (line 66, column 7) and disclose a SBCR of diameter $D_T > 15$ cm operating at gas velocities $U_G > 2$ cm/s.
- Maretto et al. (USP '902) disclose gas velocities in the range 3-200 cm/s, but more preferably in the range of 10-40 cm/s.
- The large differences in the above values of D_T and U_G indicate that the *quantitative* effects of reactor size and gas velocity have not been well understood in the prior art and that a good deal of confusion exists. For example, although Krishna and Schweitzer recommend very large columns, an elaborate model by Stern et al.[6] found that "the most efficient use of a given reactor volume is obtained with small diameter reactors."

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[3] R. Krishna; A Scale-up Strategy for a Commercial Scale Bubble Column Slurry Reactor for Fischer-Tropsch Synthesis; Oil and Gas Science and Technology-Rev. **55** 2000, p. 359-393

[4] G. van der Laan, A. Beenackers, R. Krishna; Multicomponent Reaction Engineering Model for Fe-Catalized FT Synthesis in Commercial Scale Slurry Bubble Column Reactors; Chem. Eng. Science **54** 1999, p. 5013-5019

[5] R. Krishna, S.T. Sie; Design and Scale-Up of the FT Bubble Column Slurry Reactor; Fuel Processing Technology **64** 2000, pg. 73-105

[6] D. Stern, A.T. Bell, H. Heinemann, Analysis of the Design of Bubble Column Reactors for Fischer-Tropsch Synthesis, Ind. Eng. Chem. Proc. Des. Dev. **24** 1985, p. 1213-1219

[7] D. Schanke, P. Lian, S. Eri, E. Rytter, B.H. Sannaes, K.J. Kinnari, Optimization of Fischer-Tropsch Reactor Design and Operations in GTL Plants; Natural gas conversion VI : proceedings of the 6th Natural Gas Conversion Symposium : June 17-22, 2001, Alaska, USA; in Studies in Surface Science and Catalysis, **136** 2001, p. 239

DIFFERENCE BETWEEN THE PRIOR ART AND THE CLAIMS AT ISSUE

- The Herbolzheimer, Steynberg, and Maretto patents ('982, '031, '902) recommend operation of FT SBCRs in plug flow of the gas phase, preferably $Pe_G > 1$ or $Pe_G >> 1$, but at least $Pe_G > 0.2$, while the Zhang et al. application claims operation at $Pe_G < 0.175$.
- The Schweitzer et al. patent (Pub. No. US 2003/0109590 A1) teaches the benefits of well-mixed flow in the liquid phase in order to achieve better product selectivity and temperature control of the reactor, but it does not suggest strong mixing in the gas phase. On the contrary, paragraph [0019] references EP-B-0 450 860 which teaches that the gas phase Peclet number should be larger than 0.2 *to avoid significant backmixing* (i.e. to ensure the highest productivity according to paragraph [0017].) Further, the essential recommendation in Schweitzer concerning gas superficial velocity is $U_G < 35$ cm/s to maintain low attrition of the catalyst, which is not related to the central idea of the Zhang et al. patent application (i.e. the degree of mixing of the gas phase.)
- The Clark et al. patent (US 6,156,809) teaches a low per-pass conversion, multi-staged process for FT synthesis using preferably Fe catalysts. The object of the invention is to minimize water production by the WGS reaction and hence to achieve a H_2/CO consumption ratio close to 2 to closely match the composition of syngas produced from a natural gas feed. No mention is made concerning the optimal hydrodynamic conditions in a FT SBCR, neither can these be implied, since the gas velocity U_G and the tower diameter D_T are not specified in the description of the invention.
- The Eri et al. patent (US 5,116,879) teaches the composition of a preferred catalyst for Fischer-Tropsch Synthesis (FTS), but merely mentions the types of reactors which could be used for FTS, as well as typical conditions of temperature, pressure, H_2/CO ratio, and space velocities used in FTS. It does not provide any information concerning D_T, U_G, or the flow conditions for an optimally designed reactor system.
- In view of the cited differences, it is my opinion that none of the above references disclose nor anticipate the invention of the Zhang et al.

FURTHER EVIDENCE CONCERNING OBVIOUSNESS OR NONOBVIOUSNESS OF THE ZHANG ET AL. APPLICATION

- No prior reference directly teaches or suggests that strong mixing in the gas phase, namely $Pe_G < 0.175$, corresponds to optimum performance for an FT SBCR.
- It turns out that optimal design and operation of FT SBCRs according to the Zhang et al. invention (i.e. $Pe_G < 0.175$) corresponds in practice to operating large columns (say, $D_T > 1$ m) at high gas velocities (say, $U_G > 20$ cm/s), which is consistent with predictions by other investigators such as Schweitzer and Krishna. This mere fact, however, does not in my opinion indicate obviousness of the Zhang et al. invention because:

(a) These results themselves (i.e. large columns, high U_G) are not obvious under the prior art to a person of ordinary skill in the art, considering the large variations in opinions on the subject (described above.) In fact, Krishna and coworkers[5] themselves have recognized that their predictions are "best estimates based on cold-flow experimental studies" and that "in order to avoid costly failures on a commercial scale, it is often considered *necessary* to build a 'hot' demonstration unit for purposes of validating the scaling rules and gaining operating experience." As best expressed by Schanke et al.[7], "the ability to optimize the design and operation of [FT SBCR] *must* rely on a *complete* and *quantitative* understanding of the coupling between catalyst properties, reaction kinetics, mass transfer effects, and reactor hydrodynamics." From my review of the literature of SBCRs, it is clear to me that such a complete and quantitative understanding of SBCRs has not been disclosed in the prior art.

(b) The connection between these results (i.e. large columns, high U_G) and the invention of Zhang et al, i.e. that optimal performance corresponds to strong mixing in the gas phase, is only obvious in retrospect. Indeed, the state of prior art generally holds that efficient mixing in the gas phase corresponds to poor performance, not optimal design. Note that Krishna and coworkers failed to even mention gas-phase mixing characteristics (in term of D_G or Pe_G) in their papers[3,4,5].

- Based on the above information, I find the evidence to be strongly in favor of nonobviousness for the Zhang et al. application.

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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United States Court of Appeals for the Federal Circuit

99-1043

ECOLOCHEM, INC.,

Plaintiff-Appellant,

v.

SOUTHERN CALIFORNIA EDISON COMPANY,

Defendant-Appellee.

Clifton E. McCann, Lane, Aitken & McCann, of Washington, DC, argued for plaintiff-appellant. With him on the brief was Andrew C. Aitken.

Ted G. Dane, Munger, Tolles & Olson, of Los Angeles, California, argued for defendant-appellee. With him on the brief was Gregory P. Stone.

Appealed from: United States District Court for the Central District of California

Judge Richard A. Paez

United States Court of Appeals for the Federal Circuit

99-1043

ECOLOCHEM, INC.,

Plaintiff-Appellant,

v.

SOUTHERN CALIFORNIA EDISON COMPANY,

Defendant-
Appellee.

DECIDED: September 7, 2000

Before MICHEL, CLEVENGER, and RADER, Circuit Judges.

MICHEL, Circuit Judge.

Ecolochem, Inc. ("Ecolochem") filed suit in 1992, alleging that Southern California Edison Company ("Edison") infringed Ecolochem's U.S. Patent Nos. 4,556,492 ("the '492 patent") and 4,818,411 ("the '411 patent") when deoxygenating water in the High-Flow Makeup Demineralizer ("HFMUD") at Edison's San Onofre Nuclear Generating Station ("SONGS"). Edison denied infringement, counterclaimed for declaratory judgment of invalidity, and asserted equitable defenses. By grant of partial summary judgment to Edison, the United States District Court for the Central District of California invalidated claims 1, 2, and 5-10 of the '492 patent and claims 20-21 of the '411 patent, holding the subject matter of each of these claims to be either anticipated under 35 U.S.C. § 102 and/or obvious under 35 U.S.C. § 103. On appeal to this court, we reversed the holding by the district court that there was no genuine issue of material fact that the invention of claim 20 of the '411 patent would have been obvious at the time of the invention, and remanded the case for a trial on invalidity in light of Ecolochem's evidence of secondary considerations. As to the invalidation of the other appealed claims, we affirmed. Ecolochem continued to assert infringement of claims 1, 3-13, 15, 17, 18, and 20 of the '411 patent after remand, but dropped its suit as to the remaining claims of the '492 patent. After a bench trial, the district court found that Edison had willfully infringed claims 1, 3-13, 15, 17, 18, and 20 of Ecolochem's '411 patent and rejected Edison's equitable defenses. The court then went on to invalidate all of the claims found to be infringed. Ecolochem appeals the holdings of invalidity as to claims 1, 3-13, 15, 17, 18, and 20 of the '411 patent here. Edison does not cross-appeal the district court's finding that Edison willfully infringed those claims of the '411 patent.

We affirm the district court's finding that claim 20 of the '411 patent was proven invalid by clear and convincing evidence both as anticipated under 35 U.S.C. § 102 and obvious under 35 U.S.C. § 103. We reverse its findings of invalidity for anticipation for claims 1, 4, and 7-12 because we discern clear error in the district court's finding that the prior art was proven by clear and convincing evidence to have recited every limitation of claims 1, 4, and 7-12. We also reverse the district court's conclusions that the subject matter of claims 1, 3-13, 15, 17, and 18 of the '411 patent was proven invalid for obviousness by clear and convincing evidence, as we discern clear error in the district court's implicit finding that there was motivation to combine the teachings of the prior art references. As the district court's findings of willful infringement stand unchallenged, we remand for a determination of damages.

BACKGROUND

Edison operates SONGS, a type of nuclear power plant known as a Pressurized Water Reactor ("PWR"). PWRs use water in two systems, called the "primary system" and the "secondary system." A minute amount of water from the secondary system is lost during each operation cycle. This water must be replaced, and the replacement water is commonly referred to as "make-up water." Because water in the secondary system must be of extremely high purity, make-up water is supplied from a make-up demineralization system, which takes outside source water and refines it through "demineralization," i.e., the removal of mineral ions.

During the start-up operations for SONGS, Edison decided to construct a HFMUD to meet the make-up water needs of SONGS' two active reactors. While the HFMUD was being constructed, Edison employed outside vendors, including Ecolochem, to provide the needed make-up water. Before hiring Ecolochem, Edison hired other vendors who provided poor quality water and constantly shuttled demineralization trucks on and off Edison's property to meet Edison's requirements. In the summer of 1982, Edison hired Ecolochem to provide purer quality water at the large volumes Edison needed to meet its make-up water needs. Ecolochem used a patented "Mobile Flow" trailer apparatus to provide water treatment services, which enabled it to regenerate its trailers on-site, thus avoiding the other vendors' needs to truck the impure water off-site. Ecolochem, however, was hired only to produce demineralized water, not water that had been both demineralized and deoxygenated.

The Electrical Power Research Institute ("EPRI"), a research organization for the power industry, published new guidelines in 1982, recommending the use of deoxygenated water in PWRs. These guidelines were soon implemented throughout the utility industry. In direct response to these guidelines, Edison asked Ecolochem to deoxygenate the make-up water used in SONGS. Shortly thereafter, Ecolochem began developing the patented process at issue in the instant case.

Once construction of the HFMUD was finished, Edison had no further need for Ecolochem's services, being able to now produce, on its own, sufficient, high purity, deoxygenated make-up water by passing the water through the HFMUD. The HFMUD passes the make-up water through a strong acid cation resin bed, a predominantly weak base anion resin bed, an activated carbon bed, a second strong acid cation resin bed, a strong base anion bed, and, finally, a vacuum deareator. This process removes suspended, undissolved solids and dissolved impurities, including salt, mineral ions, organic chemicals, and oxygen.

Ecolochem alleged that Edison's process, as described above, infringes its '411 patent. Ecolochem asserted all three independent claims of the '411 patent, and multiple dependent claims. The independent claims read as follows:

> 1. A deoxygenation process comprising a first step of contacting a liquid contacting [sic] dissolved oxygen and hydrazine with a bed of activated carbon to catalyze a reaction between said dissolved oxygen and a portion of said hydrazine, whereby an amount of dissolved carbon contaminants is added to said liquid, and a second step of removing said contaminants and said unreacted hydrazine that comprises passing said liquid through a strong acid cation exchange resin and a strong base anion exchange resin.
>
> 15. A deoxygenation process comprising a first step of contacting water containing dissolved oxygen and hydrazine with a bed of activated carbon to catalyze a reaction between said dissolved oxygen and a portion of said hydrazine, whereby an amount of dissolved and undissolved activated carbon contaminants are added to said water, a second step of removing said dissolved contaminants and said unreacted hydrazine by passing said water through a strong acid cation exchange resin and a strong base anion exchange resin, said water being at a temperature above the freezing point of water and below a temperature that would damage said resins, removing said undissolved contaminants by passing said water through a filter whereby said undissolved contaminants are filtered from said water, and a fourth step of circulating said water in a power generating apparatus after said removing step.
>
> 20. A deoxygenation process comprising a first step of contacting a liquid containing dissolved oxygen and hydrazine with a bed of activated carbon to catalyze a reaction between said dissolved oxygen and said hydrazine, whereby an amount of dissolved activated carbon contaminants is added to said liquid, and a second step of removing at least said dissolved contaminants by passing said liquid through a strong acid cation exchange resin and a strong base anion exchange resin.

Asserted claims 3-13 depend on claim 1. Asserted claims 17 and 18 depend on claim 15. Claim 20 is independent, and no claims dependent thereon are asserted.

All asserted claims in suit recite a deoxygenation process for removing dissolved oxygen from a liquid. In representative claim 20, liquid containing oxygen and hydrazine passes through activated carbon, thus catalyzing a reaction between the oxygen and hydrazine, whereby an amount of dissolved carbon contaminants falls out of the reaction and is added to the liquid. Then the liquid passes through ion exchange resins, including both strong acid cation and strong base anion exchange resins, to remove at least the dissolved contaminants. The invention of independent claim 1 is similar, except that the resins also remove any unreacted hydrazine. Claims 3 through 6 and claims 10 through 13 require further steps in the deoxygenation process, e.g., filtration. Claim 7 requires the temperature of the liquid to be above the liquid's freezing point, and below the temperature at which the resins would be damaged. Claim 8 requires the liquid to be water. Claim 9 requires that the liquid of claim 1 be water and that the water be circulated in a power generating apparatus. Independent claim 15 recites a combination similar to claim 9, and claims 17 and 18 add hydrazine and demineralize the water.

The '411 patent issued in 1989 from a continuation of an application which issued as the '492 patent on December 5, 1985. Both the '411 and '492 patents are entitled "Deoxygenation Process." At the outset of this litigation, Ecolochem asserted claims under both the '492 and '411 patents.

On September 1, 1994, Judge Gadbois, the original trial judge, granted-in-part and denied-in-part Edison's motion for summary judgment seeking to invalidate various asserted claims of Ecolochem's patents. See Ecolochem, Inc. v. Southern Cal. Edison Co., 863 F. Supp. 1165 (C.D. Cal. 1994). Judge Gadbois held claims 1, 2, and 5-10 of the '492 patent and claims 20 and 21 of the '411 patent to be invalid as either obvious and/or anticipated. Ecolochem appealed the partial summary judgment as to claims 1, 2, 5-7, and 10 of the '492 patent and claim 20 of the '411 patent. Ecolochem did not appeal the findings of invalidity of claims 8 and 9 of the '492 patent or claim 21 of the '411 patent. We affirmed the district court's holdings of anticipation of claims 1, 2, 5, and 6 and obviousness of claims 7 and 10 of the '492 patent. We reversed the summary judgment of obviousness of claim 20 of the '411 patent and remanded the case for a trial weighing the secondary consideration evidence as to claim 20. See Ecolochem, Inc. v. Southern Cal. Edison Co., No. 95-1230, 91 F.3d 169 (Fed. Cir. June 5, 1996) (table).

Upon remand, the case was randomly reassigned to Judge (now Circuit Judge) Richard A. Paez to conduct a trial on claim 20 and the remaining claims upon which summary judgment had not been granted in the earlier district court decision. Ecolochem asserted infringement with respect to claims 1, 3-13, 15, 17, 18, and 20 of the '411 patent. See Ecolochem, Inc. v. Southern Cal.

Edison Co., No. 92-3436, slip op. at 9 (C.D. Cal. 1998) ("Ecolochem"). After a bench trial, Judge Paez found that Edison had willfully infringed claims 1, 3-13, 15, 17, 18, and 20 of Ecolochem's '411 patent. Judge Paez, however, held claims 1, 3-13, 15, 17, 18, and 20 of the '411 patent to be invalid for obviousness and claims 1, 4, 7-12 and 20 also to be invalid as anticipated.

Ecolochem appeals the rulings of the district court that claims 1, 4, 7-12, and 20 were anticipated and that the inventions of claims 1, 3-13, 15, 17, 18, and 20 would have been obvious. Edison does not cross-appeal the district court's findings of willful infringement.

We have jurisdiction under 28 U.S.C. § 1295(a)(1) (1994).

ANALYSIS

I. Anticipation

A. The Martinola Reference

The district court found claims 1, 4, 7-12, and 20 of the '411 patent to be anticipated by either of two articles, one published in 1980 and the other in 1981, by Dr. Friedrich Martinola and a co-author, both of which are entitled "Saving Energy by Catalytic Reduction of Oxygen in Feedwater." See Dr. Friedrich Martinola & P. Thomas, Saving Energy by Catalytic Reduction of Oxygen in Feedwater, in Proceedings of the 41st International Water Conference Pittsburgh 77 (1980); Dr. Friedrich Martinola and P. Thomas, Saving Energy by Catalytic Reduction of Oxygen in Feedwater, in Effluent and Water Treatment Journal 542 (December 1981). Because these two articles are in most aspects identical, we refer to them together throughout as "the Martinola reference." We review the district court's decision on anticipation after trial for clear error. See Lindemann Maschinenfabrik GmbH v. American Hoist and Derrick Co., 730 F.2d 1452, 1462, 221 USPQ 481, 488 (Fed. Cir. 1984).

The district court focused on Figure 10 of the Martinola reference (which is the same figure in both articles). Figure 10 shows a few possible uses for deoxygenated water, such as supplying make-up water for boilers, or for nuclear reactors. The figure is essentially a flow chart indicating various ways for the water to be deoxygenated, depending on the potential destination of the water. Water designated for nuclear reactors is shown flowing through three steps: demineralization, and then a two-step deoxygenation process, which is accomplished by passing the water through a catalyst column and a mixed bed. The district court interpreted Figure 10 as showing that the catalyst column can contain either the Lewatit catalyst or activated carbon. The district court found that the reactant can be either hydrogen or hydrazine.

On the face of the 1980 Martinola article, which fails to provide a detailed description of Figure 10, there is a bold heading reading: Application of oxygen reduction in water with hydrogen. Beneath this heading are two paragraphs of text, followed by Figure 10. The text reads:

> The process is recommended wherever the heat used for thermal degassing cannot be recovered. It will therefore be primarily used where the work has to be carried out at ambient temperature or where there is no heating steam available.
>
> Fig. 10 shows a few suggested applications. It also includes systems for the simultaneous treatment of water with ion exchange resins and oxygen reduction with catalysts.

Martinola at 81-82 (1980). The 1981 article, on the other hand, has no bold headings, but discusses Figure 10 in more detail. The paragraph directly following Figure 10 reads:

> [T]he application of hydrogen to reduce oxygen in water is recommended wherever the heat used for thermal degassing cannot be recovered. It will therefore be primarily used where the work has to be carried out at ambient temperature or where there is no heating steam available.
>
> Figure 10 shows a few suggested applications.

Martinola at 546 (1981). The latter description clarifies that Figure 10 is not meant to illustrate the use of either hydrogen or hydrazine, but only hydrogen, contrary to the findings of the district court in the instant case. This is particularly apparent when we examine the differences between the two articles. The heading in the 1980 article clearly illustrates that Figure 10 refers only to hydrogen, and the discussion in the text explains only that Figure 10 shows a few applications. The 1981 article does not limit Figure 10's applications to hydrogen through a heading, but states clearly in the text ("the application of hydrogen to reduce oxygen . . . . Figure 10 shows a few suggested applications.") that the suggested applications are for the utilization of hydrogen to reduce oxygen in water.

We hold that the district court clearly erred in finding that the articles anticipate claims 1, 4, 7-12, and 20 of the '411 patent. Each article is entitled "Saving Energy by Catalytic Reduction of Oxygen in Feedwater." Each article discusses methods to deoxygenate water, dividing the methods in use at the time of the article into physical processes (vacuum degassing at low temperatures and pressure degassing at high temperatures), and chemical processes (reduction with sulfite, hydrazine or hydrogen). The articles state that the physical processes (or thermal degassing) have been the most common method of deoxygenating, as the chemical processes are expensive, slow to react at low temperatures, and contaminate the water by adding salts. The articles then state that the chemical process of deoxygenating water with hydrazine had been in use, but that the chemical process of deoxygenating water with hydrogen had not been, and concludes that the hydrogen process is preferable. At the end of the articles is a comparison of the thermal degassing method, the hydrazine method, and the hydrogen method. The articles state that:

> Precondition for the proper use of hydrazine is the pH-value of the water to be higher than 8.5, because only in this range the reaction with oxygen takes place with sufficient rate. . . . When applying activated carbon as a catalyst in the removal of oxygen with hydrazine at ambient temperatures it has to be taken into account that the carbon releases salts into the demineralized water.

Martinola at 81 (1980); Martinola at 545-46 (1981). The articles then conclude that "[i]f we compare the final costs for all three processes . . . we find that the method of oxygen reduction with hydrogen is much cheaper than the other methods. The required apparatus is also simple and needs virtually no maintenance." Martinola at 81 (1980); Martinola at 546 (1981). This conclusion is followed by a discussion of how to use water deoxygenated by hydrogen in different industries, as illustrated by Figure 10. Only in that discussion is there a suggestion to follow the catalyst column with a mixed bed if one plans to use water deoxygenated by hydrogen in nuclear power plants. The articles do not discuss the use of water deoxygenated by any other method in nuclear power plants. The articles' discussion of applications of deoxygenated water is limited to the use of hydrogen deoxygenation.

The district court in the instant case disagreed with the earlier discussion of the Martinola reference by the district court in Ecolochem, Inc. v. Mobile Water Tech. Co., 690 F. Supp. 778 (E.D. Ark. 1988), aff'd, 871 F.2d 1096, 10 USPQ2d 1557 (Fed. Cir. 1989) (table). In the earlier case, the district court held that:

> [t]he diagram found on page 82 of the Martinola article is under the bold-faced heading "Application of oxygen reduction in water with hydrogen." [See Martinola at 81 (1980)] (emphasis supplied). Thus, the diagram refers to applications of the process the authors are trying to promote--the palladium/hydrogen catalysis--and not the hydrazine process which is discussed in a separate section. This conclusion is buttressed by the fact that the palladium/hydrogen process may also release ionic impurities into the effluent, see id. at 79 ("traces of chlorides or other ions may be released"), thus necessitating a downstream ion exchange resin when high purity deoxygenated water is required. . . . Nothing in the Martinola reference expressly teaches the use of a mixed bed ion exchange resin following the hydrazine/carbon process.

Id. at 781-82. This is to be contrasted with the district court in the instant case, which wrote:

> [T]he Court respectfully disagrees with the district court's conclusion in Mobile Water that because Diagram 10 is positioned on the page following the heading "Application of oxygen reduction in water with hydrogen" and the associated text, Diagram 10 necessarily refers exclusively to reduction of oxygen in water with hydrogen and not to reduction of oxygen with hydrazine in an activated carbon column. . . . There is no room for Figure 10 at the bottom of page 81 because Figure 9 extends too far down the page. Following Figure 9 is a brief conclusion to the article, in which the authors recommend use of the Martinola system whenever deoxygenation is to be carried out at ambient temperatures. . . . Thus, Figure 10 refers generally to methods of deoxygenating and purifying water.

Ecolochem, slip op. at 80-81.

The district court clearly erred by misconstruing Figure 10's relationship to the text of the article. As discussed above, this becomes even clearer once we examine the difference between the two articles. Dr. Martinola and his co-author very carefully made sure in both the 1980 article, through the heading, and the 1981 article, through the language, that Figure 10 refers only to hydrogen and not to hydrazine. The authors would not have been so careful with the language in the 1981 article if they had not meant for Figure 10 to come under the "hydrogen-only" heading in the 1980 article. We disagree with the district court in this case that the publishers rather than the authors chose where to place Figure 10. Rather, we agree with the Arkansas district court that the authors intended the placement of Figure 10 under the hydrogen-only heading, and that Figure 10 therefore only refers to applications of the palladium/hydrogen catalysis. The district court, we hold, clearly erred in finding that Martinola anticipates deoxygenation by hydrazine in combination with a mixed bed. Consequently, we reverse the district court's finding that the Martinola reference was proven by clear and convincing evidence to have anticipated certain of the asserted claims of the '411 patent.

B. The Martinola Presentation

The district court also found the same claims -- 4, 7-12, and 20 -- of the '411 patent to be anticipated by a public presentation made by Dr. Martinola at the International Water Conference in Pittsburgh in October 1980. Specifically, the district court found that "Martinola stated at his deposition that during his presentation at the 1980 conference he used Figure 10 of his diagram [sic] as a slide and discussed 'the use of a mixed bed ion exchange resin after hydrazine and activated carbon' for the same purposes and uses described in Ecolochem's patents." Ecolochem, slip op. at 84 (quoting Martinola Dep. at 18:16-19:6). Finding this to be undisputed, the district court found that this testimony established that the Martinola presentation, like his articles, anticipated the above claims of Ecolochem's '411 patent. See id.

Ecolochem argues that "Dr. Martinola's oral presentation must stand or fall with the article as allegedly anticipatory prior art, since Dr. Martinola could not remember in 1992 what he had said twelve years earlier." Appellant's Br. at 35. We do not agree that the presentation, in and of itself, cannot anticipate claims of the '411 patent. Section 102 provides that "a person shall be entitled to a patent unless . . . the invention was known or used by others in this country." 35 U.S.C. § 102(a) (1994). A presentation indicative of the state of knowledge and use in this country therefore qualifies as prior art for anticipation purposes under § 102. Furthermore, whether Dr. Martinola correctly remembered his presentation twelve years later is an issue of credibility, on which we review the district court's finding with deference. The district court found, based on Dr. Martinola's testimony, that Figure 10 was indeed presented in 1980 by Dr. Martinola with an explanation that it was addressing the use of hydrazine. See Ecolochem, slip op. at 84.

The key element of the presentation, found by the district court to anticipate the claims of the '411 patent, is Figure 10. We first note that both independent claims 1 and 15 differ from independent claim 20 in contemplating that the final ion exchange step will remove not only dissolved carbon contaminants, but also any excess hydrazine that has not reacted with the dissolved oxygen in the water. Claims 4 and 7-12 (which all depend on claim 1) also require the additional step of removing the excess hydrazine. According to his deposition testimony, Dr. Martinola discussed the removal of the dissolved carbon contaminants at the 1980 presentation, but not the removal of excess, i.e., unreacted, hydrazine. This omission renders clearly erroneous the district court's finding that claims 1, 4, and 7-12 were anticipated by Dr. Martinola's presentation, and consequently we reverse that finding.

Therefore, the only claim that could be anticipated is claim 20, which claims a deoxygenation process comprising the steps of passing liquid containing oxygen and hydrazine through activated carbon, and then passing the liquid through ion exchange resins, including both strong acid cation and strong base anion exchange resins, to remove at least the dissolved contaminants. This is the exact process described by Dr. Martinola's presentation of Figure 10. We therefore affirm the district court's finding of anticipation of claim 20 of the '411 patent as not clearly erroneous.

II. Obviousness

The district court also held that the inventions of claims 1, 3-13, 15, 17, 18, and 20 of the '411 patent would have been obvious in light of the "combination of the Houghton process for deoxygenation with a mixed bed ion exchange resin to remove excess hydrazine and/or dissolved and/or undissolved carbon contaminants." Id. at 78. We review the district court's conclusion of obviousness de novo. We affirm the district

court's conclusion of obviousness with regard to claim 20, and reverse the holding that obviousness was proven by clear and convincing evidence with regard to all other claims at issue.

A. The Houghton Process as a "Blueprint"

The district court essentially found that the most innovative aspect of Ecolochem's process was its "[u]nearthing [of] long-neglected art," holding that "Ecolochem's good fortune in obtaining the Houghton reference just as the EPRI guidelines created increased attention in the PWR industry to the problem of ambient temperature deoxygenation does not entitle Ecolochem to patent protection." Id. at 69.

Houghton was the co-author of a paper on deoxygenation by carbon catalysis of the reaction between hydrazine and dissolved oxygen, entitled "The Use of Active Carbon With Hydrazine in the Treatment of Boiler Feed Water" ("the Houghton article"). The Houghton article was presented at the 1957 International Water Conference at Bournemouth, England and brought to the attention of Ecolochem at the 1982 International Water Conference. The Houghton article peaked the interest of Ecolochem, and its scientists began performing experiments to determine if the results predicted in Houghton's paper could be replicated in a laboratory setting. Ecolochem's scientists were skeptical, because they "had understood that hydrazine reacted very slowly with dissolved oxygen and one of [their] objectives in [the] preliminary experimentation was to run the process to determine if the Houghton process sufficiently catalyzed the reaction." Miller Decl. ¶ 22. The tests supported the Houghton article, but also revealed the presence of ionic substances in the deoxygenated water coming out of the carbon bed. Houghton did not discuss the ionic contamination. Ecolochem performed subsequent tests to assess its attempts to reduce the presence of the ionic substances, and after considerable experimentation, eventually succeeded with the patented process after more research and considerable experimentation. The district court found that "for years it had been known in the art of water treatment that activated carbon releases ionic substances into water," but that Ecolochem's scientists, who the district court found had been employed in the water treatment industry for over a decade by the time the patent issued, were unaware of

this contamination at the time they conducted their experiments. Ecolochem, slip op. at 23.

The district court recognized that the Houghton reference did not anticipate the patent, but felt that:

> Taken together, the prior art references relevant to Ecolochem's invention disclose all of the elements of the claimed invention, and their combined teachings would have suggested to one of ordinary skill in the art that the Houghton process could be followed by the use of mixed bed ion exchange resins to provide ambient temperature deoxygenation and remove excess hydrazine as well as dissolved and undissolved carbon contaminants.

Id. at 72.

"A patent may not be obtained . . . if the differences between the [claimed invention] and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art." 35 U.S.C. § 103(a) (Supp. III 1997). Our analysis of the patentability of Ecolochem's invention begins with the phrase "at the time the invention was made." Here, the date of the invention is presumed to be the filing date of the parent application, December 16, 1983.

In In re Dembiczak, we noted that:

> Measuring a claimed invention against the standard established by section 103 requires the oft-difficult but critical step of casting the mind back to the time of invention, to consider the thinking of one of ordinary skill in the art, guided only by the prior art references and the then-accepted wisdom in the field.

In re Dembiczak, 175 F.3d 994, 999, 50 USPQ2d 1614, 1617 (Fed. Cir. 1999). We "cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." In re Fine, 837 F.2d 1071, 1075, 5 USPQ2d 1780, 1783 (Fed. Cir. 1988).

Our case law makes clear that the best defense against hindsight-based obviousness analysis is the rigorous application of the requirement for a showing of a teaching or motivation to combine the prior art references. See Dembiczak, 175 F.3d at 999, 50 USPQ2d at 1617. "Combining prior art references without evidence of such a suggestion, teaching, or motivation simply takes the inventor's disclosure as a blueprint for piecing together the prior art to defeat patentability--the essence of hindsight." Id.

"When a rejection depends on a combination of prior art references, there must be some teaching, suggestion, or motivation to combine the references." In re Rouffet, 149 F.3d 1350, 1355, 47 USPQ2d 1453, 1456 (Fed. Cir. 1998) (citing In re Geiger, 815 F.2d 686, 688, 2 USPQ2d 1276, 1278 (Fed. Cir. 1987)). The same principle applies to invalidation. "Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination." ACS Hosp. Sys., Inc. v. Montefiore Hosp., 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984). Although the suggestion to combine references may flow from the nature of the problem, see Pro-Mold & Tool Co. v. Great Lakes Plastics, Inc., 75 F.3d 1568, 1573, 37 USPQ2d 1626, 1630 (Fed. Cir. 1996), "[d]efining the problem in terms of its solution reveals improper hindsight in the selection of the prior art relevant to obviousness," Monarch Knitting Mach. Corp. v. Sulzer Morat Gmbh, 139 F.3d 877, 880, 45 USPQ2d 1977, 1981 (Fed. Cir. 1998). Therefore, "[w]hen determining the patentability of a claimed invention which combines two known elements, 'the question is whether there is something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination.'" In re Beattie, 974 F.2d 1309, 1311-12, 24 USPQ2d 1040, 1042 (Fed. Cir. 1992) (quoting Lindemann, 730 F.2d at 1462, 221 USPQ at 488).

In this case, the district court used the '411 patent as a blueprint, with the Houghton process as the main structural diagram, and looked to other prior art for the elements present in the patent but missing from the Houghton process. The district court opinion does not discuss any specific evidence of motivation to combine, but only makes conclusory statements. "Broad conclusory statements regarding the teaching of multiple references, standing alone, are not 'evidence.'" Dembiczak, 175 F.3d at 999, 50 USPQ2d at 1617. The district court provides no support for its broad conclusory statement that it was known in the art that a carbon bed, as used in the Houghton process, would produce water with high levels of conductivity caused by the presence of ionic contaminants. Nor does the district court then provide support for its implicit finding that given water so contaminated, it would be obvious to one of ordinary skill in the art to place a mixed bed ion exchange resin downstream of the carbon bed. In fact, nowhere does the district court particularly identify any suggestion, teaching, or motivation to combine the Houghton process with a mixed bed ion exchange resin to achieve the patented process.

The district court avoids the issue, and makes implicit findings, but can point to nothing that suggests the combination of deoxygenation and demineralization processes that comprise Ecolochem's invention. For instance, the district court finds that Ecolochem "did not try any other way to remove the ionic contaminants leached by the carbon bed other than adding the mixed bed," Ecolochem, slip op. at 24, and that "[t]here is no evidence that any system for production of ultra-pure water ever included a carbon bed as the final step in water treatment." Id. at 45. In addition, the district court makes the unsupported

finding that "[m]any in the art knew as of 1982 that carbon beds leached contaminants which could be removed by ion exchange." Id. at 44. In support of this statement, the district court relies upon the Martinola reference, and U.S. Patent No. 4,430,226 ("the '226 patent") for a disclosure that "activated carbon leaches dissolved contaminants." For the disclosure of the "removal of dissolved carbon contaminants by ion exchange", the district court relied upon the '226 patent and John W. Hassler's 1974 article "Purification with Activated Carbon," which do state that with some types of carbon, "ion-exchange resins have been employed to remove inorganic compounds, alkalinity, or acidity not absorbable by activated carbon." J.A. at 1893. However, while these references teach the leaching of dissolved contaminants by activated carbon and the use of ion-exchange resins to remove carbon contaminants, neither reference suggests combining, nor provides any motivation to so combine, the two elements of the Ecolochem process, i.e., deoxygenation of the water by the Houghton process and demineralization of the water by the mixed bed.

The district court seems to find that the Martinola reference implicitly suggests the combination of the two elements, but discounts "[t]he fact that Martinola did not make Ecolochem's invention, and instead focused on the hydrogen-palladium method of deoxygenation [a]s not relevant." Id. at 82. The district court clearly erred in this regard. This fact is completely relevant to the obviousness analysis, since Martinola actually teaches away from combining at least one of the Martinola articles with the Houghton process to achieve Ecolochem's claimed process. While the Martinola reference describes a hydrogen and Lewatit-based deoxygenation process and mentions deoxygenation by carbon catalysis of a hydrazine/oxygen reaction, it does so only for comparative purposes. The Martinola reference actually unfavorably compares the hydrazine/carbon process, saying that it "releases salts into the demineralized water" and that the hydrogen-based process is energy saving and significantly less expensive.

The Martinola reference is not the only reference that points to problems and concerns with the Houghton process. The Houghton article was challenged from the day it was presented, when an audience member asked whether the process could produce water with acceptable amounts of silica. Houghton responded that contamination was a concern with his process, and both this inquiry and the response were published with the paper in a section entitled "Discussion." Another paper published contemporaneously with the Houghton article states that:

> if an activated carbon-bed is used to accelerate the oxygen/hydrazine reaction, it is particularly important that no trace of carbon should enter the boiler . . . [i]f it is considered essential that the hydrazine and oxygen should react before entering the boiler, then the use of ultra-violet light is a promising means of accelerating the reaction, without introducing any impurities into the system.

S.R.M. Ellis, C. Moreland, The Reaction Between Hydrazine & Oxygen, in The Account of the Proceedings of the International Conference held at Bournemouth, 15th-17th May 1957 8, 21 (1958). In 1960, T.F. Demmitt prepared a "Preliminary Report on the Use of Activated Carbon as a Catalyst for the Dissolved Oxygen-Aqueous Hydrazine Reaction." Demmitt stated that "[m]agnetite would be more desirable than activated carbon since there would be no tendency to 'deactivate' magnetite in filtered water," and thereby taught away from the idea of using a carbon bed as the catalyst. J.A. at 1696H. In 1962, a paper was presented at the International Water Conference, stating that research had shown two methods "to remove oxygen to sufficiently low levels with adequate capacities to be practical." Piero Sturla, Polishing Condensate and Dearating by Ion Exchange at 63 (1962). Neither of these methods was based on the Houghton process. These two methods were still being used in 1977, when Culligan (a water treatment company) recommended one of the two in an internal memo for use in portable containers, and the challenges continued through the time of the invention. Even Ecolochem's scientists themselves testified that, prior to their successful tests, they did not believe they would be able to replicate the results stated in the Houghton article.

Furthermore, the district court found even the mixed bed, of which the use "to remove carbon contaminants was well known in the field," had detractors. Ecolochem, slip op. at 82. Edison's own engineers testified that they considered:

> a four-bed [a primary cation bed, a primary anion bed, a secondary cation bed and a secondary anion bed] system superior to . . . a three-bed system [a cation bed, an anion bed and a mixed bed] . . . because of the problems that Edison had encountered in regenerating the mixed bed, . . . and based on . . . personal experience that four-bed systems generally outperformed mixed bed systems in producing pure water.

Id. at 27. There is clear evidence of teaching away in the prior art from both the demineralization process and the deoxygenation process used by Ecolochem, and no evidence that there was any suggestion in the prior art to combine these two processes, yet the district court finds the '411 patent obvious in light of the prior art.

The absence of a convincing discussion of the specific sources of the motivation to combine the prior art references, particularly in light of the strength of prior art teaching away from the use of the Houghton process, is a critical omission in the district court's obviousness analysis, which mainly discusses the ways that the multiple prior art references can be combined to read on the claimed invention. For example, the district court finds that the invention of claim 20 would have been obvious, and that, although claims 1 and 15 differ from claim 20, "[e]ach of the additional steps of claims 1 and 15 is disclosed in the prior art." Id. at 48. The opinion then lists each step and states where in the cited prior art references the step can be found. This reference-by-reference, limitation-by-limitation analysis wholly fails to demonstrate how the prior art teaches or suggests

the combination claimed in the '411 patent.

With hindsight, we could perhaps agree that the Houghton article seems like an obvious place to start to address the need in the power plant industry for an improved carbon-catalyzed deoxygenation process employing hydrazine that can be used commercially in a variety of applications. But, "obvious to try" is not the standard. As embodied in the '411 patent, the process would secure for the art all of the advantages that catalyzation of a reaction normally provides without prohibiting its use due to all of the incumbent disadvantages associated with the use of hydrazine. However, the incumbent disadvantages associated with the use of hydrazine to deoxygenate water as described in the Houghton article include the release of unwanted impurities into the water, including dissolved substances such as salts, organic chemicals and suspended solids. As a result, the industry widely regarded the Houghton process as too impractical to be used for large amounts of water, or for high purity deoxygenated water. Under the conditions in which PWRs operate, even minute amounts of these contaminants can adversely affect generator integrity. See id. at 6. Variations on this method had been tried, but discounted in favor of other deoxygenation processes. Dr. Martinola himself testified that at the time of his presentation he stated that the hydrazine method of deoxygenation led to contaminated deoxygenated water. See supra at I.B. Finally, the process not only worked, but worked better than expected, leading Edison to investigate "why Ecolochem's equipment can reduce [the organic concentration in the water] to less than 10 p[arts] p[er] b[illion] with a device not designed to [do so]." Ecolochem, slip op. at 30. Edison, in fact, gave four prospective bidders for the HFMUD construction job a tour of Ecolochem's equipment and shared "information about Ecolochem's process with others in violation of [Ecolochem's] secrecy agreement." Id. Only after this sharing of information and subsequent testing was a prospective bidder able to develop the process used in the HFMUD, and accused by Ecolochem of infringing the '411 patent. The district court in fact found that the bidder's "proposed system . . . effectively copied Ecolochem's deoxygenation process." Id. at 32. This evidence undermines the district court's conclusion that Ecolochem's process would have been obvious to one of ordinary skill in the art.

Because we do not discern any evidentiary basis for the finding by the district court that there was a suggestion, teaching, or motivation to combine the prior art references cited against the claimed invention, the district court's conclusion of obviousness cannot stand. The implicit generalized finding by the district court that, when one of ordinary skill in the art was faced with the problem of deoxygenating water for use in a nuclear power plant and the Houghton article, the combination claimed by Ecolochem in the '411 patent would have been obvious is insufficient. We have previously held that "[t]he suggestion to combine may be found in explicit or implicit teachings within the references themselves, from the ordinary knowledge of those skilled in the art, or from the nature of the problem to be solved." WMS Gaming, Inc. v. International Game Tech., 184 F.3d 1339, 1355, 51 USPQ2d 1385, 1397 (Fed. Cir. 1999). However, there still must be evidence that "a skilled artisan, confronted with the same problems as the inventor and with no knowledge of the claimed invention, would select the elements from the cited prior art references for combination in the manner claimed." In re Rouffet, 149 F.3d at 1357, 47 USPQ2d at 1456; see also In re Werner Kotzab, 217 F.3d 1365, 1371, 55 USPQ2d 1313, 1317 (Fed. Cir. 2000) ("[A] rejection cannot be predicated on the mere identification . . . of individual components of claimed limitations. Rather, particular findings must be made as to the reason the skilled artisan, with no knowledge of the claimed invention, would have selected these components for combination in the manner claimed."). Here, there was no such evidence presented. The only evidence on this issue presumes the very problem at hand--two experts testified that "if someone of ordinary skill in the art had been given the Houghton reference in 1982 and [if] they were asked to make it usable in a high-pressure power plant, they would have come up with Ecolochem's invention." Ecolochem, slip op. at 64 (emphasis added). The evidence available, however, indicates that if one of ordinary skill in the art had been given the Houghton reference, they would not have been inclined to use it, due to the large amount of teaching away, and the reliance in the industry on vacuum degasifiers to deoxygenate water. This finding by the district court presumes the knowledge acquired from Ecolochem's patent. We hold that the district court's finding that a skilled artisan would combine these references was clearly erroneous, and we hold that on this record the district court clearly erred in finding clear and convincing evidence of a suggestion to combine the prior art references, a suggestion to use the Houghton article as the backbone of the invention. Therefore, we reverse the district court's conclusion of obviousness with regard to claims 1, 3-13, 15, 17, and 18 of the '411 patent. As to claim 20, however, our prior decision mandates that we now undertake further analysis respecting its invalidation by the district court.

B. Prima Facie Case of Obviousness of Claim 20

We previously held in our June 1996 non-precedential decision that:

> the district court clearly mischaracterized the import of Demmitt as a prior art reference for the determination of obviousness of claim 20. Demmitt . . . did not disclose the removal of carbon contaminants with an ion exchange resin. Despite the district court's mischaracterization of the importance of Demmitt, Ecolochem concedes that there is a 'prima facie case of obviousness before Demmitt and there remains one after.' However, Ecolochem argues that the secondary considerations, in this case, could rebut the prima facie case and that the district court wrongly failed to consider its evidence of secondary considerations and conclude that the evidence raised a genuine issue of fact requiring trial. We agree. . . . For the foregoing reasons . . . the trial court's holding of obviousness of claim 20 of the '411 patent is reversed, and the case is remanded for trial on validity and infringement as to claim 20.

Ecolochem, slip op. at 9-12. Given our earlier reliance on Ecolochem's concession of the prima facie obviousness of claim 20, which is binding as law of the case, we must treat claim 20 separately from the other claims held obvious in the decision

appealed herein. We may only conclude that Ecolochem rebutted the prima facie case of obviousness with regard to claim 20 if the evidence of secondary considerations supports such a holding. See id.; In re Piasecki, 745 F.2d 1468, 1471, 223 USPQ 785, 787 (Fed. Cir. 1984). We therefore review the district court's findings on the evidence of secondary considerations, and, for purposes of completeness, address whether and how this evidence affects the adjudicated invalidity of all other asserted claims.

C. Evidence of Secondary Considerations With Regard to All Claims

The idea that a patented invention might appear to be obvious given the excellent vision accorded by hindsight, but might not have been obvious at the time the invention was made, was discussed by the Supreme Court in Graham v. John Deere Co., 383 U.S. 1, 17-18 (1966). In the intervening years since Graham a great deal of attention has been paid to the importance of secondary considerations. We discuss below many of the secondary considerations used by the courts in an effort to compensate for hindsight. The Supreme Court held that "[s]uch secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy." 383 U.S. at 17-18 (internal citations omitted). While we review the district court's factual findings on the secondary considerations for clear error, we review the ultimate determination of obviousness de novo. See B.F. Goodrich Co. v. Aircraft Braking Sys. Corp., 72 F.3d 1577, 1582, 37 USPQ2d 1314, 1317-18 (Fed. Cir. 1996). We find clear error in the district court's findings on several of the secondary considerations as discussed below, but upon reviewing the obviousness conclusion de novo, hold that even if corrected, the findings respecting secondary considerations support the district court's holding of obviousness of claim 20 in the instant case. This conclusion has no effect on the obviousness of the inventions of claims 1, 3-13, 15,17, and 18, which we have already held would not have been obvious given the absence of any motivation to combine the teachings of the cited prior art references. Ecolochem has, however, failed to rebut the conceded prima facie case of obviousness with regard to claim 20. We therefore affirm the district court's conclusion that the invention of claim 20 would have been obvious.

1. Long-Felt But Unsolved Need

The district court found that "[t]he findings of fact do not support Ecolochem's contention that there was a long-felt but unsolved need to create an ambient temperature deoxygenation process for use in start-up and restart of nuclear power facilities." Ecolochem, slip op. at 73. It went on to hold that even if there had been such a need, the "required nexus between the claimed invention and the long-felt need is attenuated by the increased market demand resulting from adoption of the EPRI guidelines in 1982." Id.

Ecolochem argues that the 1982 EPRI guidelines merely reflected the acknowledged need for deoxygenated water that arose in the late 1970s and that the regulations only recommended, rather than required, deoxygenated water. Ecolochem further argues that there were reasons other than the issuance of these regulations for it to develop its processes. Furthermore, it argues that its mobile chemical process was the only way to meet this long-felt but unsolved need for deoxygenated water during the time required to build and install the permanent deoxygenators. Ecolochem argues that the guidelines (like emissions requirements for automobiles) were issued only after a long-felt need was realized, and that the regulations may have been unattainable at the time they were issued. Even Edison in its brief pointed out that Ecolochem had the only practical solution to the need of SONGS for deoxygenated and demineralized water before the completion of the HFMUD.

Our review of the district court's finding of no long-felt but unsolved need is for clear error, a deferential standard of appellate review. We cannot say the district court's finding that Ecolochem produced demineralized water in response to the guidelines issued by EPRI to be clearly erroneous. The record shows that the guidelines urging the use of deoxygenated water were issued in 1982, and Ecolochem filed for a patent on its deoxygenization process on December 16, 1983. This evidence supports the district court's finding that Ecolochem's process was developed not in response to a long-felt need in the power industry, but in response to a shortly-felt requirement imposed by EPRI's guidelines.

2. Commercial Success

We have previously held that a party cannot "demonstrate commercial success, for purposes of countering the challenge of obviousness, unless it can show that the commercial success of the product results from the claimed invention." J.T. Eaton & Co. v. Atlantic Paste & Glue Co., 106 F.3d 1563, 1571, 41 USPQ2d 1641, 1647 (Fed. Cir. 1997). We have further held that a presumption arises that the patented invention is commercially successful "[w]hen a patentee can demonstrate commercial success, usually shown by significant sales in a relevant market, and that the successful product is the invention disclosed and claimed in the patent." Id. In the instant case, Ecolochem offered evidence that its invention was practiced at 28 plants and generated almost $13 million in revenue from 1983 to 1990. Once Ecolochem made the requisite showing of nexus between commercial success and the patented invention, the burden shifted to Edison to prove that the commercial success was instead due to other factors extraneous to the patented invention. See id.

At trial, Edison countered that the commercial success of Ecolochem's process was due solely to the fact that it was part of a mobile apparatus, and that since none of the claims at issue include such a mobility limitation, the commercial success factor favors a finding of obviousness in the instant case. The district court found that both Edison and Ecolochem had carried their

respective burdens, finding that the volume of Ecolochem's sales satisfied the requirements to show commercial success, but also that Edison proved the commercial success was due to factors other than those claimed. The district court explained:

> Ecolochem's limited commercial success with its patented process was primarily attributable to (1) Ecolochem's ability to meet the need in the PWR industry for short-term emergency services through its Mobile Flow service; (2) Ecolochem's ability to provide deoxygenation services while PWR plants built permanent deaeration equipment to meet new EPRI standards; (3) Ecolochem's head start in marketing mobile deoxygenation treatment services through use of its patented Mobile Flow trailer; (4) the increased blowdown rates that resulted from the 1982 tightening of EPRI guidelines for salts in the steam generator. In short, Ecolochem's commercial success was due not to the nature of the claimed invention, but to other economic and commercial factors unrelated to the technical quality of the patented process.

Ecolochem, slip op. at 74-75.

The district court's finding, however, ignores Edison's own statements to the contrary. Edison indicated in its briefs that it chose Ecolochem because the "first vendors Edison hired provided poor quality water and constantly shuttled demineralization trucks on and off Edison's property to meet Edison's capacity requirements." Appellee's Br. at 3. Edison's brief also states that Ecolochem's process "enabled it, unlike Edison's previous vendors, to regenerate its trailers on-site and provide purer quality water at the large volumes Edison needed." Id.

These statements make it clear that the commercial success of Ecolochem's product was, in fact, based on two factors: the improved filtration process, and the mobility of the commercial embodiment. Edison did not differentiate the improved filtration process from the patented process in any way, focusing only on the missing limitation of mobility in the claims at issue. The success was due to both the mobility, undisputedly not covered by the claims, and to the improved filtration process, undisputedly covered by the claims. Edison had the burden of disproving that the improved filtration process contributed to the success of the invention, and its own brief undermines its argument, by conceding the benefits of Ecolochem's filtration process. See Ryko Mfg. Co. v. Nu-Star, Inc., 950 F.2d 714, 716, 21 USPQ2d 1053, 1055 (Fed. Cir. 1991) ("To overturn a patent, the challenger must clearly prove those facts which support patent invalidity."). Consequently, the district court clearly erred in finding that Edison met its burden of proving that the success of the invention was due to factors not claimed in the patented invention.

3. Failure of Others to Make Invention

In evaluating this factor, the district court held that an unsolved problem is not evidence of non-obviousness unless skilled workers in the art have tried and failed to solve the problem. SeeEcolochem, slip op. at 75. The district court then held that Ecolochem did not show that others had tried but failed to make Ecolochem's invention. See id.

Ecolochem cited a 1986 internal business memorandum circulated at Arrowhead, a competitor of Ecolochem's. In this memorandum, under the heading "OPPORTUNITY," Arrowhead wrote the following: "Ecolochem claims a proprietary process for deoxygenation and has exploited this market with little or no interference from Arrowhead. Markets exist primarily at the nuclear plants. Several approaches for deoxygenation exist. . . ." J.A. at 3049.

Edison, in turn, responded with testimony from its employees that when Edison discussed its deoxygenation needs with contractors in 1982, only two contractors mentioned chemical deoxygenation: Arrowhead and Ecolochem. Edison employees further testified that vacuum degasifiers were the industry standard, were reliable and economical, and that every other contractor stated that it intended to deoxygenate with a vacuum degasifier. There was no testimony as to whether Arrowhead succeeded in making a working chemical deoxygenation device. The district court evaluated Edison's testimony, and the absence of any testimony contradicting it, and found that no competitor had attempted to employ a chemical deoxygenation process. The failure of others is therefore reduced to a credibility question, whether the district court believed the Edison employees. "This court gives great deference to the district court's decisions regarding credibility of witnesses." Carroll Touch, Inc. v. Electro Mechanical Sys., Inc., 15 F.3d 1573, 1580, 27 USPQ2d 1836, 1842 (Fed. Cir. 1993) (citing Anderson v. City of Bessemer City, 470 U.S. 564, 575-76 (1985)). We cannot find it clearly erroneous on the part of the district court to have found no evidence of failure by others to make a chemical deoxygenation device or develop such a process.

4. Simultaneous Invention

"The fact of near-simultaneous invention, though not determinative of statutory obviousness, is strong evidence of what constitutes the level of ordinary skill in the art." The Int'l Glass Co. v. United States, 408 F.2d 395, 405 (Ct. Cl. 1969). "[T]he possibility of near simultaneous invention by two or more equally talented inventors working independently, . . . may or may not be an indication of obviousness when considered in light of all the circumstances." Lindemann, 730 F.2d at 1460, 221 USPQ at 487.

The district court found that "prior to the issuance of Ecolochem's patent, Todd Hook of NWT independently combined the

Houghton process with a mixed bed ion exchange resin, thereby independently developing Ecolochem's invention." Ecolochem, slip op. at 75-76. Ecolochem argues that Mr. Hook testified at trial that the:

> idea embodied in his test apparatus, which combined the hydrazine/carbon process and ion exchange, was not his but Dr. Sawochka's. Dr. Sawochka, an acknowledged expert in the field, provided the system sketch and configured the test apparatus embodying the idea. Obviousness or nonobviousness to experts is irrelevant to obviousness under Section 103. Competing innovation by Dr. Sawochka may show bias but nothing more.

Appellant's Br. at 56. Edison responds by stating that "as both Sawochka and Hook testified, Hook was left largely on his own in performing his project." Appellee's Br. at 53.

The issue of simultaneous invention is directly tied to the level of knowledge attributable to one of ordinary skill in the art. The district court weighed the testimony discussed above, and determined that there was evidence of simultaneous invention, and the fact that the one who performed the experiment was supervised by one of extraordinary skill in the art did not enhance the former's level of knowledge. Essentially, the district court found that this secondary consideration factor favors obviousness. As this was based on the district court's determination that Dr. Sawochka's and Mr. Hook's testimony was credible, we must give that finding great deference. Consequently, we cannot discern clear error in the finding of simultaneous invention by the district court.

5. Teaching Away

The district court found that "Ecolochem presented no evidence that the prior art expressed skepticism concerning the efficacy of using the Houghton process or of combining the Houghton process with ion exchange. Likewise, the Court's findings of fact establish that the prior art did not teach away from Ecolochem's invention." Ecolochem, slip op. at 77. Ecolochem argued that the Houghton process had been around for decades and was not well known or regarded, citing a number of articles stating concerns with the Houghton process.

We previously found, in our unpublished June 1996 decision, that Ecolochem had put forth evidence "that various references taught away from the invention as they warned against the Houghton process because of the carbon contaminants." Ecolochem, Inc. v. Southern Cal. Edison Co., slip op. at 11. We discussed above the fact that Martinola teaches away from the Houghton process, as that reference found the process inefficient and expensive. We also discussed above the history of prior art teaching away from Houghton. Based on the body of evidence pro